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TIGHT-FILL FRUIT PACKING

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THE TIGHT-FILL FRUIT PACKING METHOD consists of filling a container in a random manner with sized fruits, to meet grade standards; settling the fruit by vibration; and tightly fastening the lid to compress the top padding upon the fruit. When properly done, there is no opportunity for fruit movement in transit, thus reducing fruit injury.

THIS CIRCULAR describes the tight-fill packing system and discusses all necessary procedures and requirements for those who want to use this new fruit packing system. It was developed over the past ten years to improve packing and handling of fruit, and to keep it competitive in the marketplace. It has been in commercial use for pears, plums, and apricots, and in limited commercial use for nectarines and peaches. Experimental results indicate that the method also may be useful for cherries and the less tender apple varieties.

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TIGHT-FILL FRUIT PACKING

Tight-fill fruit packing was developed as an integrated system of postharvest fruit handling that makes possible a high-volume output of high-quality fruit. It saves labor and materials, and also provides a pack well suited to modern merchandising methods, including repackaging and bulk displays.

In recent years, many cost-saving improvements have been made in fruit production and harvesting operations. To keep fruit competitive, packing and handling methods must also be made more efficient, and the requirement of skilled workers must be reduced.

Today's shortage of skilled labor and the short harvest season of most fruit crops make it difficult and costly to get or train a sufficient number of packers. However, skilled packers are essential for the "place-packing" methods that have been used widely. These methods generally require hand placing of two or more layers of fruit in a specific pattern into a rigid lug or box, using some combination of wraps, cups, trays, baskets, shims, liners and pads to aid in positioning and protecting the product. The resulting packages are to immobilize the fruit and at the same time to cushion the fruit against impacts. Fruit must be carefully selected for size so that the completed layer is laterally tight. Smaller fruits, such as cherries and apricots, often are packed by first facing with two layers of hand-placed fruits in an inverted container, and then filling the container from the bottom with loose fruit. Packages often are overfilled to allow the fruit to be compressed, so the packages bulge during lidding. The lateral tightness of the hand pack and this compression serve to immobilize the fruit during handling and transit.

Older packing methods often caused injury

A successful new packing method must consider all factors contributing to mechanical injury of fruit.

Types of injuries. Mechanical fruit injuries consist of open wounds and bruises. Most open wounds (cuts, punctures, and abrasions) can be easily recognized as caused by defective handling or packaging: cuts by rough handling during packing, dumping, or lidding; punctures by injury from a hard object, such as a fruit stem, during handling, packing, or transit; and abrasion by the fruit rubbing against a rough surface—the picking container, the packing belt, or the shipping container.

The cause of bruises (impact, compression, and vibration) are harder to identify. Impact bruises result from a sharp blow, such as a fruit falling against another fruit or against a hard surface. They occur during harvest or packing, or during handling of the packed containers. Compression bruises are caused by excessive pressure on the fruit, usually from lidding or stacking of containers. Both impact and compression bruises appear as circular, cone-shaped flesh injuries which may or may not turn brown, and cannot always be noticed on the fruit surface (figure 1).

Vibration bruising, often called "roller bruising" or "belt burn," results from repeated and prolonged vibration of the fruit against an adjacent surface. Such injury can occur whenever the fruit is in motion; during transit to the packing facility, during movement through the packing system, or during subsequent distribution. This bruise appears as an unsightly browning on the fruit surface

Fig. 1. Bruising injury of pears. Top row shows vibration bruising which damages the fruit surface but does not extend into the flesh. Lower row shows impact bruising which may not be visible on fruit surface, but extends well into flesh.

which makes it more difficult to market (figures 1, 2). The injury also makes it easier for rot organisms to enter, and speeds moisture loss and physiological activity of the fruit, thus shortening storage or shelf life, or both.

Older packing methods. Many features of older packing methods were developed by trial and error in an attempt to reduce fruit bruising. Improved padding of fruit packing equipment has helped to protect the product from impact bruising. Packing materials within the package have provided added protection. Techniques of immobilizing the fruit have been useful in preventing vibration bruising during the transit.

Past attempts to develop new packing methods often failed because no provision was made for fruit protection. A loose-pack has been tried with many fruits as a substitute for existing place packs. This loose-pack was prepared by random filling of fruit into a container. A pad and lid were sometimes used. The fruit was not immobilized unless the container was overfilled and the fruit compressed during lidding. Such overfilling could result in serious compression bruising. Any fruit which was loose within the container was likely to be seriously damaged by vibration bruising during transit. In such cases, damage in transit

differed widely, depending on differences in the transport vehicles, type of ride, and even the ability of the particular container or fruit to absorb vibrations. Thus, the loose-pack method greatly reduced the labor and packing material requirements, but did not protect deciduous fruits during handling and transport.

These mechanical injury problems were carefully considered in the development of the tight-fill pack. Vibration settling prevents loosening of the contents after packing, thus fruit remains immobilized during transit. The tight-fill packing method maintains a slight presure on the fruits without container bulge. The result is a reduction of vibration and compression bruising problems.

Fig. 2. Vibration injury in a commercial plum pack shipped to eastern market in loose pack. The bruising, although visible in this picture only in some fruit, appears in a browning of the fruit.

DEVELOPMENT OF TIGHT-FILL PACKING

Long-term studies have indicated the following advantages of tight-fill packing:

- Fruit can be delivered to market in better condition than hand-packed fruit.
- Mechanization of fruit-packing procedures is possible.
- The resulting package is adaptable to handling procedures during distribution, consumer packing, and display.

Shippers contemplating conversion to this new packing method should consider its adaptability to specific fruits; its effect on their packing facilities, labor requirements, and packing and handling costs; and its effect on marketing. Tight-fill fruit packing is not complicated, but it should be thoroughly understood before being adopted—careful attention to every detail is essential to success.

Requirements of a new fruit packing system

Any new packing procedure must be viewed as an integral part of the overall fruit handling operation including transport, dumping, sorting, packing, cooling, and car loading. Your present equipment may not necessarily be satisfactory for a new system. Efficiency will improve only if your packing line is carefully designed and your equipment is selected or developed to facilitate the necessary handling procedures. How much mechanization is required will depend on the scale of your operation. Give careful attention to the packinghouse layout regardless of how much of it is mechanized.

Nature of tight-fill packing

Tight-fill packing includes random filling of a container, normally with sized

and graded fruit; settling the fruit by carefully controlled vibration; padding the top of the fruit; and tightly fastening the container lid to compress the top padding upon the fruit. When done properly, no part of the procedure will damage the fruit. During vibration settling, the fruit is not compressed, but is rather moved into voids which were left during filling. In the resulting package, individual fruits are held firmly in place and cannot move during transit.

The tight-fill packing method, if done properly, results in a highly uniform pack. In contrast, most hand-pack methods vary with the skill of the individual packer. Studies of trial shipments showed that average injury of tight-filled plums was less than half when compared to standard packing methods. The reduction of injury in peaches and nectarines was about one-fifth. Just as in a poorly prepared place pack, however, fruit injury can be severe if tight-fill is not done properly.

Tight-fill packing is an improvement over the loose pack method because the latter makes no provision to immobilize the fruit, and affords no protection against transit injury.

The tight-fill pack offers the same advantages as the loose-pack method: it makes more mechanization possible and thus reduces packinghouse labor requirements. Machinery may be substituted for labor in many of the packing operations if justified by the economics of labor and equipment costs and length of packing season. The degree of mechanization also depends on how much labor is available in the packinghouse during critical harvest periods.

The receiver also benefits from the tight-fill pack. Because most fruit is sold in either a consumer package or bulk display, it must be removed from the shipping container prior to sale. The absence of wraps, cups, trays, baskets, shims, or dividers in the tight-fill pack greatly facilitates this rehandling.

The tight-fill pack looks somewhat different than the place-pack. Buyers may be reluctant to accept the random pack appearance of tight-fill for fear that it may indicate an inferior pack. A sustained promotion program is necessary to convince buyers that this pack will deliver fruit in better condition than other packs, and that the elimination of some packing frills can also reduce their handling costs.

REQUIREMENTS FOR TIGHT-FILL PACKING

Tight-fill packing requires a specific sequence of carefully performed steps. Each operation is essential to the satisfactory delivery of the product to market. No step can be left out or altered without endangering the success of the system. Careful adherence to all packing steps will result in a superior pack and enhance both the immediate sale of the fruit and future acceptance of the packing system.

Need for careful sorting

Sorting systems used with other packing methods are not necessarily good enough for tight-fill packing. In hand-packing operations the initial fruit sorting is usually followed up by a second sorting when the fruit is placed in the container. This second sorting is not possible with tight-fill packing. Thus initial sorting must be thorough.

To facilitate sorting, every part of the fruit must be easily seen by the worker. Various rotating devices may be used to achieve this: rollers may slowly turn the fruit as it advances. Or, to minimize fruit scuffing, spaced, revolving rollers may pass over an advancing belt, turning the fruit very slowly. Both rollers and belt

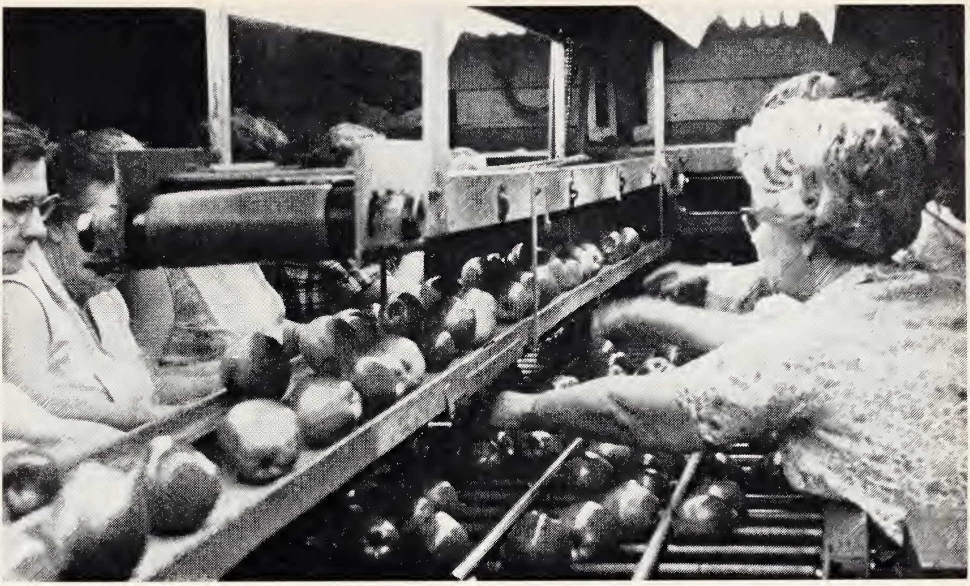


Fig. 3. Fruit sorting table is divided into lanes. Each worker sorts only in a single assigned lane. Fruit is turned slowly as it advances.

have independent speed adjustments (figure 3).

A series of narrow belts, with workers stationed alternately on each side, may be preferable to a single wide belt in assuring that no part of the fruit is hidden from view. Where space limitations dictate the use of a single wide belt, turning devices may be helpful in altering the position of the fruit.

Adequate sorting space is very important. The belt must have sufficient capacity to accommodate the most difficult sorting job, because no further quality check is possible during the packing process.

Selecting the container

The container must have sufficient stacking strength to protect the contents from compression, and must resist bulging after closing and during storage and transit. The requirements of the container will vary depending on whether it is to be used for immediate shipment or long-term storage. Both corrugated-paper and wood containers can be designed so they will provide the necessary strength.

Two-piece corrugated paper containers of full telescope design have proven satisfactory. Such containers are well-adapted to the filling and closing procedures used in tight-fill packing, and to inspection and display during handling and marketing.

Corrugated paper containers must withstand high humidity during cooling and storage without serious deterioration. They need not be designed for multi-pallet stacking in storage, however. Present economics favor the use of some type of stacking frames or pallet support rather than an extra-strength container.

Two methods are used to provide sufficient stacking strength of corrugated paper containers under high humidity conditions. One method consists of constructing a container with excessive initial strength so that it will still protect the fruit after the container has lost part of its strength from high humidity. The other method consists of treating the container or the corrugated paperboard to resist moisture absorption. Moisture

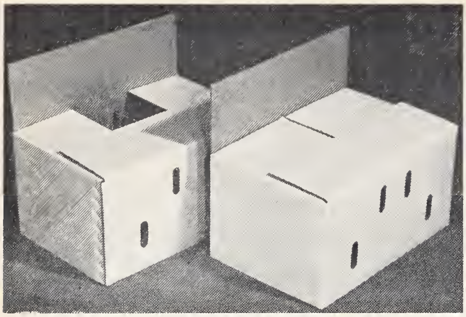


Fig. 4. Corrugated container must be constructed to resist bulging. Background container—HSC (half slotted container) construction—permits bulging in the center part of lid and body. Container in foreground—AFM (all flaps meet) construction—provides more uniform resistance to bulging in all parts of container.

resistance in paper containers is provided during manufacture by dipping in hot wax; by applying plastic-wax materials to their surfaces; or by impregnating components of the corrugated paperboard with wax or resin during manufacture. If surface coatings are used alone, both surfaces of the corrugated paperboard must be coated. If only one surface is treated, the material can act as a barrier to trap moisture within the paperboard and hasten its collapse.

Stacking strength is only one requirement of the container. Successful tight-fill packing also depends on preventing container bulge. Thus both bodies and lids must be capable of maintaining pressure on the pack during storage and transit. This requires balanced construction between body and lid and can best be provided by a container designed so that all flaps meet (AFM construction, figure 4). Two-piece telescope containers, AFM construction, in which both body and lid are made of 275-pound test corrugated paperboard, curtain coated on both surfaces, have performed well in commercial shipments.

If wood is used, all shook, including lids, must be thick enough to resist bulging and to maintain pressure on the fruit during transit. Thin slat lids or thin paper-laminated wood veneer lids and bottoms have not been adequate to prevent fruit movement during transit. A liner in wooden containers will prevent fruit scuffing. Chipboard liners and other single-thickness materials have given good protection. Untreated corrugated-paper liners in wooden containers have not proven satisfactory.

Depth of container. To facilitate uniform settling, use containers that are three to four times as deep as individual fruits are wide, regardless of your packaging material. Pears, peaches and nectarines require depths of approximately 9 to 12 inches for satisfactory results. Smaller fruits, such as apricots or small plums, may be successfully packaged in depths as shallow as 6 to 9 inches. Cherries will settle well in 4-inch containers; their containers should not be deeper than 5 to 6 inches, or compression injury may occur.

Width of container. Horizontal dimensions are important only in their effect on top or bottom bulge and on container handling. Square containers present problems in stacking, palletizing, and loading. Containers that are approximately 50 percent longer than they are wide have been used successfully. Minor adjustments may be necessary to facilitate equipment usage, fill weight, pallet stacking, or car loading. As new containers are developed it would be highly desirable to establish standard horizontal outside dimensions for use with as many fruits as possible.

The dimensions of standard containers which may legally be used in California for shipping fresh fruits are listed in the California Agricultural Code. No other container dimensions may be used unless an experimental permit is obtained. The Code now includes containers which are currently in use for tight-fill packing of certain fruits. These dimensions may be changed through appropriate action as new industry needs arise.

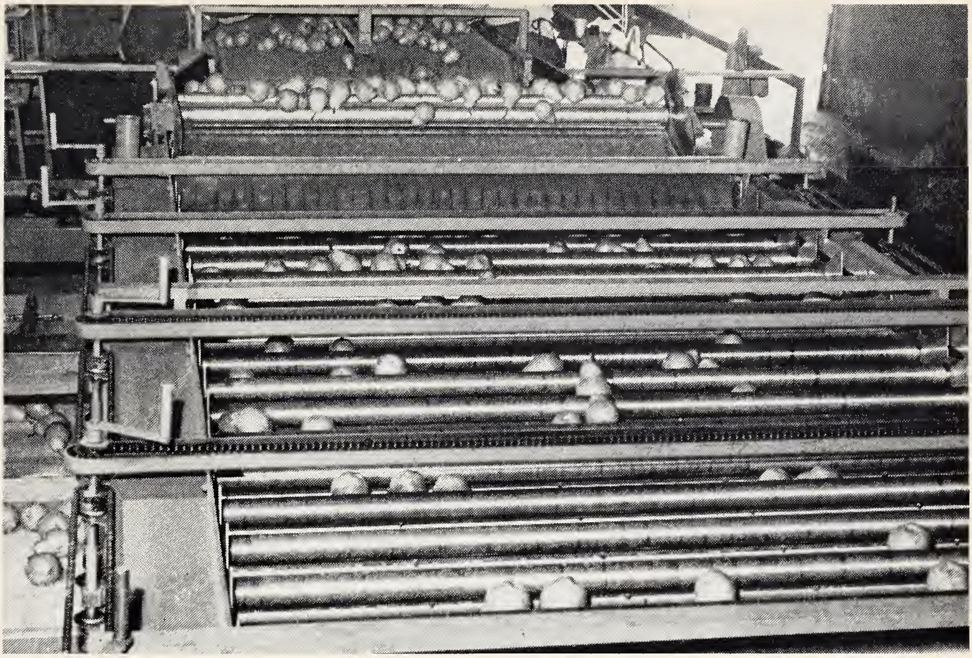


Fig. 5. Fruit being sized on drop-roll sizer. As the rolls travel toward the foreground, the space between adjacent rolls expands to allow fruit separation. Mechanical sizing must be used to provide the high-volume output essential for tight-fill packing.

Sizing

In many hand-packing operations the worker has been required to eye-size the fruit at time of packing. Sometimes a mechanical sizer has been used for rough separations, with the worker doing more exact sizing during packing. The random filling techniques of the tight-fill require the use of mechanical sizers of sufficient accuracy to satisfy standardization requirements (figure 5).

A recent unpublished study conducted by the California fruit industry established a basis to evaluate mechanical sizers for accuracy, capacity, and fruit injury. Tested were weight, slot, and diamond sizers. Weight sizers separate fruit according to differences in mass. Slot and diamond sizers measure fruit dimension—slot sizers measure one dimension, diamond sizers two dimensions. Fruit orientation on some dimension sizers is random, either static or vibrating; on others it is accomplished by fruit rotation. If selecting a sizer, consider capacity requirements, sizing accuracy, ease of adjustment, fruit injury, and adaptability to your packing facility.

An important factor in sizer selection is the coordination of the various packing line components to allow uniform fruit flow. Thus the sizer should be adaptable to the characteristics of the fruit being handled, and must permit a smooth and effective routine adjustment and operation.

Assembling corrugated paper containers

The method for assembling corrugated paper containers will depend upon how much your packing operation is mechanized. If limited volume is packed, bodies and lids may be stapled or stitched in advance of filling. A conveyor or chute system may be used to move the bodies to the filling station and the lids to the weighing and inspection station.

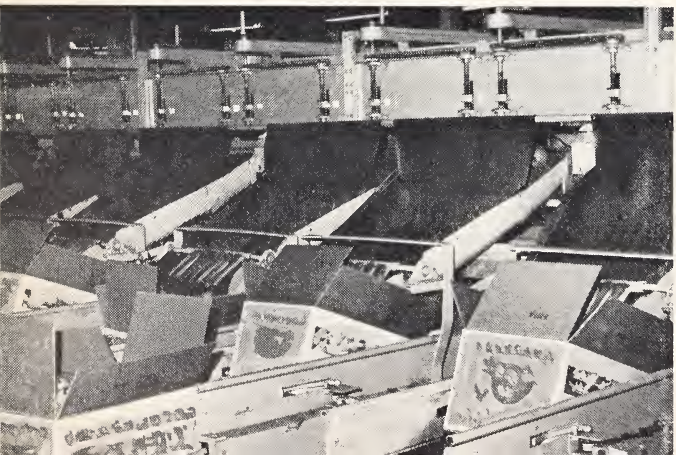


Fig. 6. Above: Table being used to assemble containers for automatic filling. After assembly, pads are placed in lids and containers are filled while inverted.

Fig. 7. Left, top: After assembly, cartons are fed into chutes to supply automatic fillers. Because each filling station bundles a single size of fruit, size designations may be applied to the cartons at this point.

Fig. 8. Left, bottom: Automatic fillers in use with pears. Empty carton tilts up to reduce initial distance of fruit drop. Containers are filled while inverted.

If the filling operation is hand assisted, the worker may set up the carton, fill the body, and then assemble the lid. In larger operations the containers may be case-sealed or closed with automatic top and bottom stapling after filling. Automatic fillers must be supplied from a container-feeding station at which the bodies and lids are folded and combined, and pads installed (figures 6, 7). The fruit size designation can also be applied to each container as the container is fed to the filler.

Filling

When random filling the container (figure 8), see to it that the fruit does not drop far. Pears have been shown to bruise in a 4-inch free drop onto a hard surface or an 8-inch free drop onto other pears. Mechanical fillers which prevent excessive drops into the container are available. Improvements are being made to combine minimum drops with high-capacity output.

Tight-fill packing depends on filling to a constant volume. Volume is normally approximated by weight, although fruit count could be used after precise sizing. For hand filling operations, have "over-under" scales located at each filling station. Automatic fillers are equipped with scales or counters to control the changing of containers.

If weight is used to estimate volume, it must be carefully determined for each variety. Once the fill weight is established, it can be standardized for all sizes of a particular variety. However, because shape and density vary, the proper fill weight may vary slightly with variety. For this reason a volume designation offers some advantages over a weight designation for marketing tight-fill containers.

Certain criteria can be used to determine the proper fill weight. Fill the container sufficiently to prevent fruit movement after settling and closing, but not so full as to cause compression bruising during closing or subsequent handling. After vibration settling, padding, and closing are completed, the container should show no noticeable bulge. A severe shake of the completed container should impart only slight movement of fruit. As the recommended pads absorb moisture, they will swell and nest around the fruit.

This initial determination of proper filling is especially critical for fruits which are highly susceptible to compression bruising. When fruits such as peaches or nectarines are packed, check the height of fill after vibration settling in a few containers, by removing the lid and top pad and by passing a straight edge across the top of the container. Individual fruits should not protrude above the top edge of the container body. Also observe uniformity of fruit settling. Large voids in the pack indicate that

Fig. 9. Check weighing of filled containers before vibration settling. Clear view of scale dial speeds this operation.

either the settling procedure is improper, the container is under-filled or the fruit is too large for the depth of the container. Because both top and bottom pads are used for these tender fruits, greater total pad swelling will occur to compensate for looseness of the fruit after packing.

Weight check

When weight is used to measure filling, all containers must pass through a weight check station (figure 9). Here the weight may be adjusted and the top fruit rough leveled. You must have enough weight stations to adequately handle the total capacity of the packinghouse. If these weight check stations are crowded, weighing will not be accurately done on all containers. The check scales should be easily read to within ¼ pound. It is not sufficient to spot weigh a percentage of containers—*every container must be weighed.*

Most hand-assisted filling operations are performed with the containers on an over-under scale. Because the workers are primarily concerned with output, this system by itself has not provided sufficient weighing accuracy. A check-weighing station is still essential to insure proper filling of all containers.

This weight check must precede vibration settling. An improperly filled container will not settle properly, and fruit injury or damage in handling and transit may result.

New developments of sizing and filling equipment may alter the need for this final weight adjustment. If a high percentage of the containers can be filled to within the ¼ pound tolerance, an automatic check-weighing station may be feasible. Such a system would divert only those packages requiring adjustment. Improved sizing accuracy would favor the use of count filling which would eliminate all weighing. Weight-check stations will continue to be essential until filling accuracy is improved.

Vibration settling

Carefully controlled vibration is used to settle the fruit in the container. When properly done, vibration settling will not cause injury, even to ripe fruit. The settling sequence consists of a short period of free vibration, during which motion is imparted to all fruit within the container, followed by a short period of vibration with a light top pressure. This top pressure does not compress the fruit; rather it causes it to move into voids which were left during filling. The entire procedure requires only a few seconds, not long enough to impart measurable vibration injury to the fruit.

Vibration accomplishes the settling which may otherwise occur during transit. Without this initial settling the fruit will be subject to subsequent loosening within the package, possibly causing vibration bruising.

Optimum fruit settling is provided by vibration of the filled containers at 800 to 1,100 cycles per minute with a vertical stroke of 3/16 to 5/16 inches imparting an acceleration of 3.0 to 3.5 g (acceleration of gravity) to the fruit. The container should vibrate without top pressure for 3 to 5 seconds, to assure that all fruit is in motion. As vibration continues, a light top pressure is applied to the fruit or the container lid for an additional 2 to 4 seconds. Top pressure is maintained until vibration ceases in order to move fruits into voids. If the vibration period is too short, the fruit will not properly settle; if too long, vibration bruising may develop—the same injury which occurs during transit. The total time for this operation should be as short as possible consistent with good settling; usually 5 to 8 seconds.

Vibration settling can be accomplished with a very simple device. A small table or box, mounted on soft springs, and fitted with motor-driven eccentric weights will satisfy the basic requirements. Although the circular motion imparted by

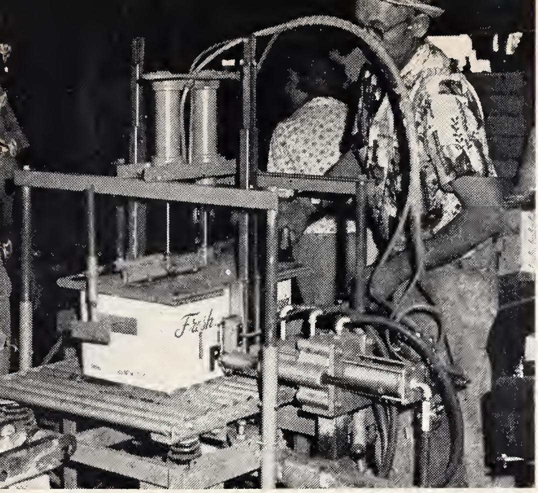


Fig. 10. Left: Vibration settling of pears. Operator applies top pressure during vibration, and staples lid to body at end of sequence.

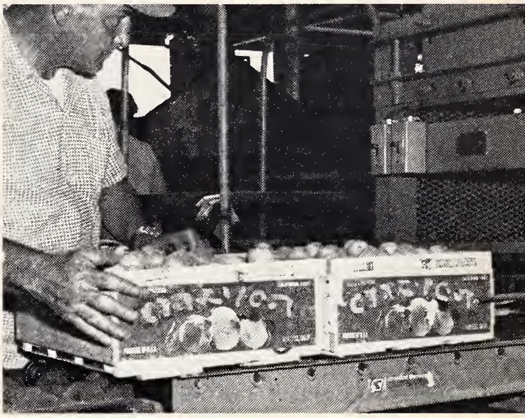
Fig. 11. Below, top: Apricots being fed to reciprocal vibration settling unit. Note fruit level above container.

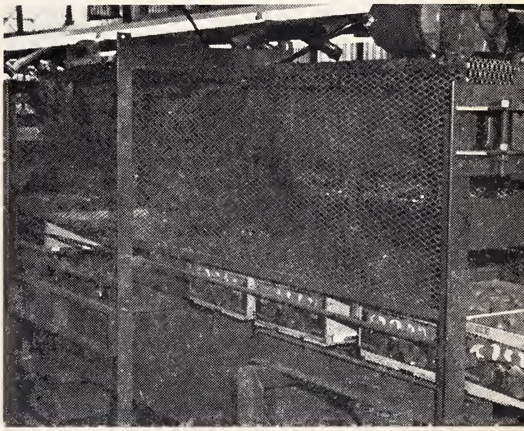
Fig. 12. Below, center: Apricots passing through reciprocal vibrator. Top pressure is applied near end of vibration sequence.

Fig. 13. Below, bottom: Tight-fill packed apricots after completion of vibration settling sequence. Note uniform, flat pack of fruit.

such a unit is satisfactory, the vertical component is most effective in settling. Straight vertical motion can be supplied to such units through the use of counter-rotating eccentric weights. The vibration table and the eccentric drive must be carefully balanced on such a unit. The natural frequency of the spring-mounted table should be well below the operating frequency. The natural frequency of the table will be under 300 cycles per minute if the springs are soft enough to be compressed ½ inch by the weight of the table.

Commercial tight-fill packing equipment is available which incorporates these basic components. One simple unit consists of a vibrating table beneath a vertical top pressure unit (figure 10). The number of containers which can be handled per hour is limited by the operator who must position each container and initiate the vibration sequence. Another unit, designed on a reciprocating principle, pulls one or more containers at a time across the vibration table and



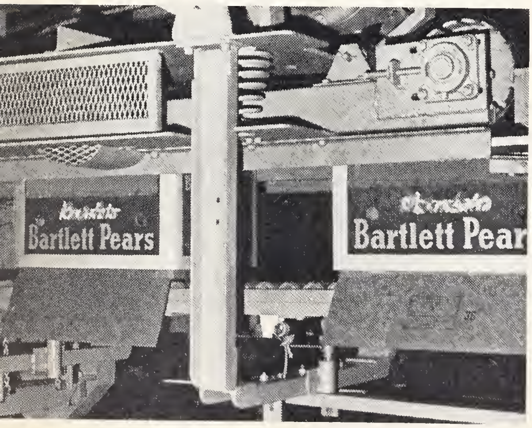


applies top pressure in sequence (figures 11, 12, 13). The number of containers that can be handled per hour is limited by length and speed of the reciprocating top pressure unit. Units are also available which pass a continuous flow of packages across the vibration table, applying pressure with a top-mounted roller conveyor (figure 14). The continuous flow of these units makes them capable of high-capacity output. Any of these units are capable of satisfactorily settling the fruit if properly adjusted.

The vibration requirements must be carefully followed to achieve good settling. Improper frequency and stroke may give you the desired acceleration but not good settling. For example, vibrators used in packing sawdust grape chests, operating at 1,800 cycles per minute and 1/16-inch stroke, will give an acceleration of about 3 g, but are ineffective in settling fruit.

You can estimate the stroke of a vibrator by firmly holding a sharp pencil in a stationary position against the unit so as to scribe the pattern of motion. With the vibrator stopped, height of the pencil line will give a close approximation of the stroke. You can estimate the frequency by calculating pulley ratios and motor speed, or you can carefully measure it with a tachometer or strobe light. When you know stroke and frequency, you can find the acceleration of the unit by using the chart in figure 15. For more precise determinations, vibration meters are available which will measure both displacement and acceleration. Although such units are relatively expensive, they can be useful in determining the proper adjustment of a vibrator.

Fig. 14. Vibration settling of pears on a continuous flow vibrator. Roller conveyor applies top pressure as vibration proceeds.



Padding

A pad must be placed over the fruit before closing the lid (figure 16). The slight compression applied during lidding nests the pad around the top fruit (figure 17). This initial compression is subsequently supplemented by pad swelling (caused by absorption of moisture) to maintain a slight pressure on the pack. This pad swelling counteracts the tendency for looseness that develops as a result of minor moisture loss and fruit shrinkage (figure 18).

Envelope pads filled approximately ½ inch thick with either redwood bark or excelsior have performed well in tests. Both have shown the ability to swell under high-humidity conditions. The excelsior wood fibers are manufactured in

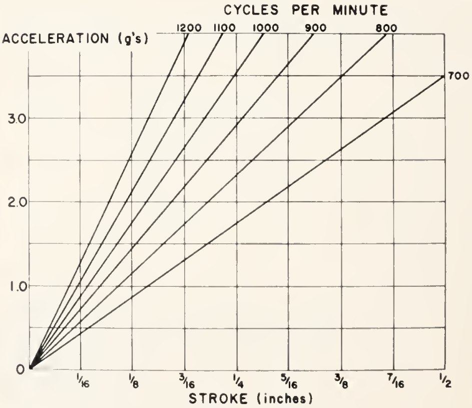


Fig. 15. To find acceleration, follow vertical line of your stroke value until it hits diagonal line of your frequency, then follow horizontal line to the left to determine acceleration of your unit.

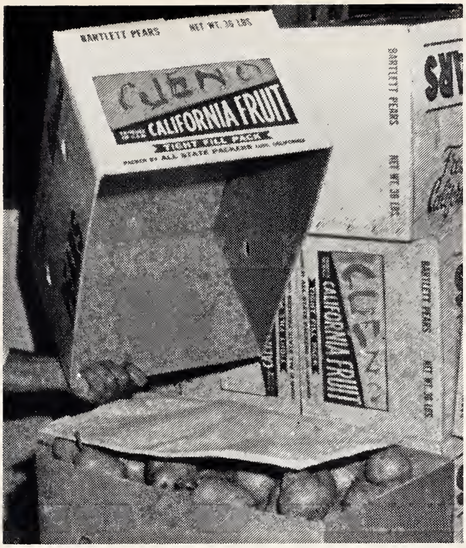


Fig. 16. Top pad is placed over fruit before lidding the container.

such a way that moisture causes them to uncurl and swell the pad. Redwood bark pads manufactured at 200 pounds per 1,000 square feet of pad and excelsior pads manufactured at 1.12 pounds per 1,000 square inches of pad (160 pounds per 1,000 square feet of pad) have given satisfactory results. Recommended minimum weights of pads of these materials may be obtained from figure 19.

A bottom pad has also been used with very tender fruits, such as peaches and nectarines, to protect against impact bruising during handling of the container. This bottom pad may be identical to that used on top of the pack. Impact bruising of these fruits can become a problem when this bottom pad is omitted.

Closing

The completed container should be closed with sufficient pressure to firmly seat the lid against the body (figure 20). A lid not fully seated may move about in transit, or other containers stacked on it may press it down and crush the fruit. If the lid is not firmly fastened, the contents may quickly loosen, causing transit bruising to the fruit.

A closing press will be needed to apply this pressure to corrugated paper containers. Some machines combine this with the top pressure unit used in settling the fruit (figure 10). The corrugated-paper container cover may be fastened to the body by stapling. A properly adjusted retractable anvil stapler permits tight closure without fruit damage (figure 21). The top pressure plate and side staplers may be combined into a single automatic unit. Closing pressures of approximately 2 pounds per square inch are satisfactory to firmly seat the lid. With proper filling and settling this top pressure will not cause fruit compression injury.

Fig. 17. Above, top: Cutaway view of pad in position over top fruit in container. Slight pressure of lidding holds pad firmly against fruit.

Fig. 18. Above, bottom: Pad after transit showing effect of swelling which caused pad to nest around top fruit in container.

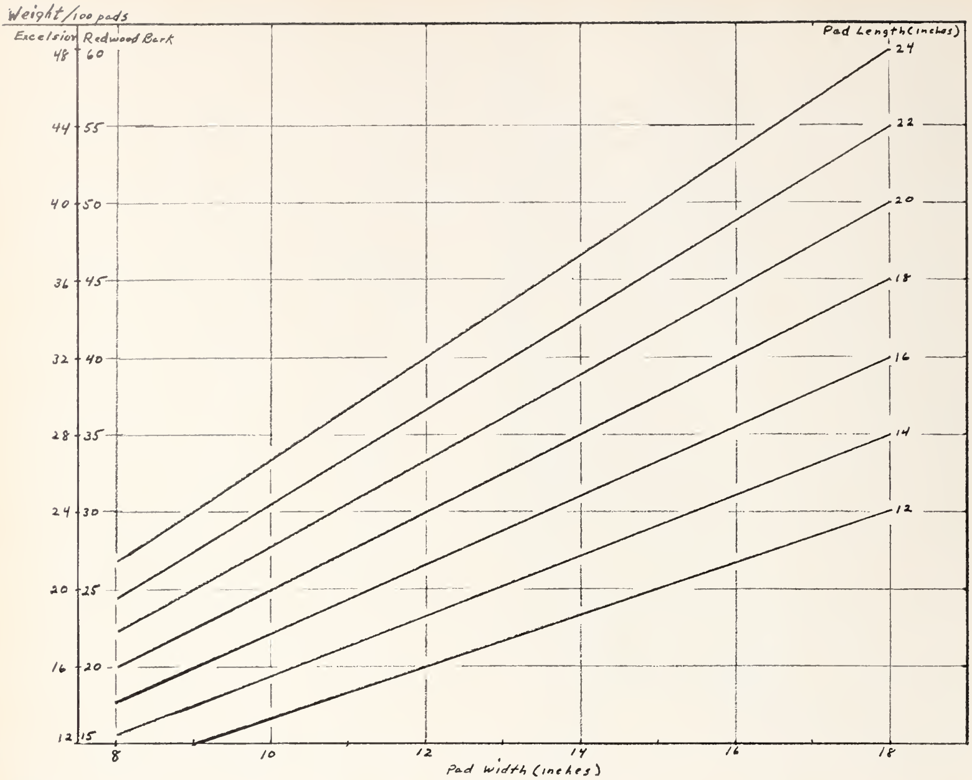


Fig. 19. To find minimum net weight per bundle of 100 pads of either excelsior or redwood bark, follow vertical line of the pad width until it intersects diagonal line of the pad length, then follow horizontal line to the left and read weight from appropriate column. Pads of these materials which equal or exceed these minimum bundle weights and are relatively uniform in thickness should perform well in tight-fill packing.

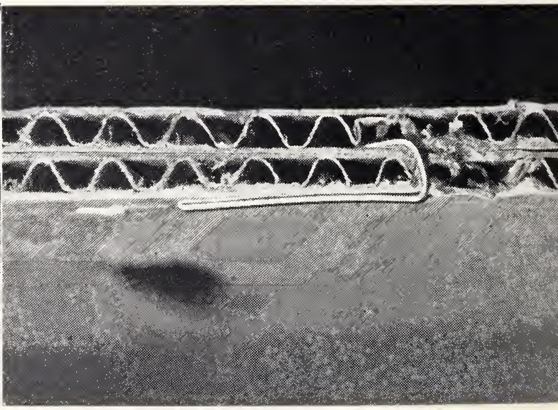


Fig. 20. Cutaway view of corrugated container showing the lid tightly seated against the rim of the body. Tight seating is necessary to maintain the tight-fill pack and thereby avoid fruit injury resulting from movement during subsequent handling.

Fig. 21. Cutaway view showing use of staple to fasten lid to body of telescope corrugated paper container. If properly adjusted the retractable anvils of the stapler tightly clinch the staple without penetration through the inside wall of the container.

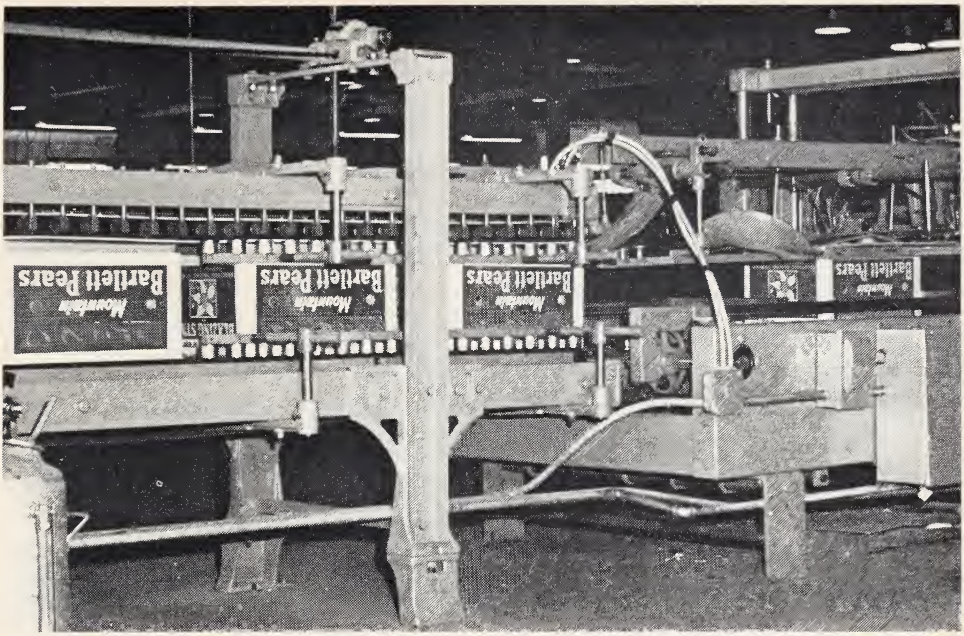
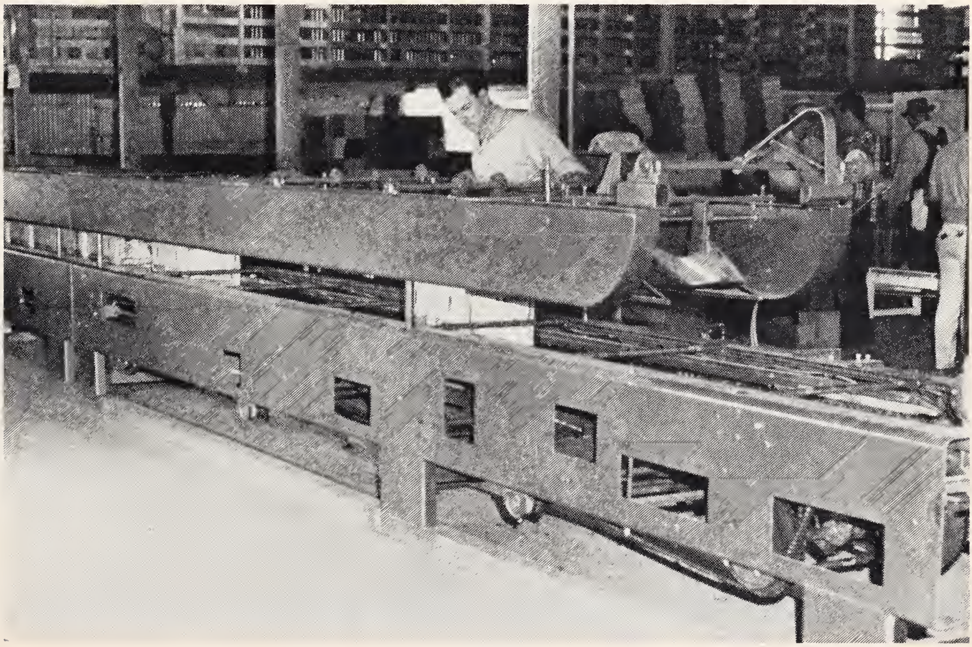


Fig. 22. Case-sealing pear cartons. Flaps are glued, folded and compressed until glue sets.

Wooden boxes may be closed with a standard lidder which applies pressure through a top platen. Platens which are contoured to fit a bulge pack are not satisfactory, and should be redesigned for a flat pack. Snap-on covers which have been designed for some wood and corrugated containers have not maintained sufficient pressure to prevent fruit movement.

Fig. 23. Automatic tight-fill packer. Single unit applies vibration settling, seals flaps, and fastens lid to body.



Some installations utilize corrugated paper containers which have been completely assembled and fastened before filling; others will require sealing after filling. If carton flaps are sealed after filling, the sealing should also come after the vibration settling. Attempts to seal filled containers before vibration settling will result in poor container closure, fruit injury, and subsequent poor settling. Both a case sealer (figure 22) and automatic top and bottom staplers, are satisfactory.

One high-capacity commercial unit combines all settling, sealing, and closing operations into a single machine (figure 23). As the container enters this machine, the flaps are folded and the fruit is settled by vibration. Following this, the flaps are opened, glued, refolded, and the glue allowed to set in a compression section. During compression, side staplers fasten the lid to the body of the container.

MANAGING THE PACKED CONTAINER

Palletizing

If room cooling is to occur after packing, space the containers on the pallet to allow cold air circulation past all surfaces (figure 24). Stability of the load must be provided with such spacing. Whenever possible, stabilize containers by cross stacking on the pallet. If this does not provide sufficient stability, you may use several alternate methods including solid stacking of top and bottom layers with spaced intermediate layers; wood or corrugated paper lath placed under the top layer of containers; or straps or twine tied around the upper part of the load. Vertical pallet spacers have occasionally been used to provide a completely rigid load. Spacers must be located so as not to interfere with air circulation around the containers. If unitized pallets are to be shipped, pallet strapping will be necessary to prevent container shift during transit.

Cooling

The fruit must be thoroughly cooled to recommended holding temperatures before loading for transit. The thoroughness of cooling should be checked by measuring the core or pit temperatures of fruit in the center of containers and pallets. Normal air cooling rates depend on container venting and spacing. Vent patterns and requirements will vary with the type of fruit and container dimensions. Corrugated paper containers have cooled satisfactorily with venting of approximately 5 per cent of the side area. A pattern which has proven effective consists of four vertical slots on each side, with two slots placed low and two slots placed high to aid air convection (see figure 24). This venting pattern also adapts the tight-fill packed containers for rapid heat removal through the use of forced-air cooling. Less or no venting is required if the fruit is thoroughly cold when packed, or if the fruit is suited to slower cooling and can be held for a longer, thorough cooling before loading.

Because considerable automation is possible in tight-fill packing, it may be

Fig. 24. Tight-fill plum containers stacked on pallets for cooling. Note cross stacking and spacing of containers.

feasible to cool the fruit *before* it enters the shipping container. The only hand operations required in a highly automated plant are fruit sorting and grading, weight adjustment, and pallet stacking. The fruit can be refrigerated through most of the packing procedure, but such a system requires efficient cooling before packing, and temperature checks as part of the packing operation. The feasibility of such a system depends on the need and economics of cooling cull fruit, the length of the delay between harvest and sorting, and the temperature requirements of the fruit.

Regardless of loading method, fruits should be thoroughly cooled before transit. Mechanical refrigeration, which has been replacing ice in transport equipment, is designed to facilitate transport of the product, *not* to serve as a portable cooler. Mechanical refrigeration in rail cars and trucks has ample capacity to maintain existing fruit temperature but not to rapidly cool the product. Thus, the fruit must be thoroughly cooled before loading.

Storage

Storage, regardless of packing method, requires a constant low temperature and high relative humidity with air velocity just high enough to prevent the development of "hot spots" in the system. Consult a refrigeration handbook for storage recommendations for specific commodities.

The storage of corrugated paper containers will pose additional problems. Such containers, even though designed to withstand high relative humidity, should receive special care in multi-pallet stacking. Use pallet frames or supports to protect the lower pallets. Permanent pallet frames in the storage room will provide complete support (figure 25). This will slightly reduce storage room capacity, but will greatly protect the container and make the fruit more accessible.

Fig. 25. Tight-fill packed pears in storage in permanent pallet racks. In this system, each pallet is independent of all others.

Various wood or metal pallet supports or "crutches" may also be used. These supports are fitted to the pallet as it is loaded. One such support consists of a piece of angle iron cut slightly less than the height of the palletized cartons, with a small flat plate welded to the top. These are placed at each corner of the pallet and secured by tying a light rope around the center of the loaded pallet. Such pallets must be carefully loaded and positioned to assure security in a storage room (figure 26).

Fig. 26. Pallet supports of "crutches" being used for tight-fill pear storage. The corner supports carry the weight of top pallets.

Fig. 27. Tight-fill packed plums loaded solid in a rail car. This method is suitable only for thoroughly cooled fruits with a fairly low respiration rate.

Loading

Corrugated paper containers nest well, and do not require stripping or blocking to immobilize them if loaded tightly into rail cars. No bracing is needed except to take up any slack in the center of the load. The load should be squeezed before placing the final tiers of containers. Solid loads of thoroughly cooled pears and plums in corrugated paper containers have carried in good condition with standard car refrigeration (figure 27).

The ability of thoroughly cooled fruits to carry successfully without air circulation depends upon their respiration rate and time in transit. Pears and plums have carried well, but the projected warming of cherries by heat released from respiratory activity during transit indicates that this fruit must have some air circulation. Projected warming rates are usually high because they are based on the assumption that no heat is removed from a solid load, while in practice some heat removal does occur. Nontheless, the projections suggest that solid loading for cherries would be extremely dangerous. Peaches, nectarines and apricots are intermediate in respiration rate and should also have air circulation.

Loads should be spaced for air circulation whenever danger exists that all fruit has not been thoroughly cooled, or where excessive warming might occur during transit. If corrugated paper containers

Fig. 28. Carloading by use of the solid-spaced pattern. Alternate tiers of containers are spaced, and immobilized through application of angle corrugated strips. Note hand-operated air stapler used to quickly fasten strips.

are spaced in the load, the ends rather than the sides should face the channel. This arrangement will minimize bulging which can weaken the container, may allow the fruit to loosen, and thus expose it to transit bruising.

For tight-fill corrugated paper containers a loading pattern has been designed which combines good temperature management with container protection and load stability. This solid-spaced pattern, illustrated in figure 28, alternates solid tiers with spaced tiers. Spaced tiers are immobilized by treated corrugated paper angles fastened to the containers. Every fruit in the load is within a reasonable distance of an air channel. The loading pattern can easily be learned, and is economical in both labor and dunnage use.

Watch the details of immobilizing the spaced tiers of this solid-spaced load. The angle corrugated paper strips are curtain coated to prevent weakening throughout transit. You may fasten them with retractable anvil staplers, but the stapler must be adjusted for solid clinching into the container. You need not staple strips to each layer of containers, but the top three layers should be stripped, and at least alternate layers below this.

Standard channel loading methods—those used in truck vans—may be used for corrugated paper containers. These channels allow sufficient air circulation to prevent the development of "hot spots." The solid-spaced load found effective in rail cars can also be used in vans if adequate air channels exist in the floor. The amount of air circulation through any spaced load depends on the fan capacity of the vehicle.

Corrugated paper containers loaded into ice refrigerator cars must be protected from moisture which collects on the ice bunker walls and adjacent floor. Containers in contact with this free moisture can be seriously weakened or collapsed, allowing loosening and shifting of the entire load. A corrugated paper sheet tacked to the bunker wall to the height of the load, and extending approximately 2 feet onto the car floor will provide this protection.

Wooden tight-fill containers require the same special loading methods used for other types of wooden containers. Spacing may be provided for temperature management using some type of strip or block loading method and bracing.

Regardless of the fruit, packing method, package or loading pattern used, you should have a complete record of the temperature of the fruit at loading. Make temperature checking a regular part of your loading operation. Open sample containers going into the load and take pulp or core temperatures of the center fruit in the box. Take repeat temperatures with each change in lot. Use these records to anticipate and prevent problems, and to relate loading condition with out-turn reports.

SPECIAL CONSIDERATIONS

Pears

Large volumes of tight-fill packed pears have been shipped commercially during recent years. Many carloads have gone to eastern receivers. This fruit is well-adapted to tight-fill packing. Because it is highly susceptible to transit bruising, loosening of the fruit, either in wrap-pack or tight-fill, must be avoided. Normal cooling of pears does not require the use of side vents in the container. Pears have carried well in solid loads provided the fruit was thoroughly cold at the time of loading.

Plums and apricots

Fairly large volumes of tight-fill packed plums and apricots are being shipped commercially with good results. Both fruits appear to be well-adapted to tight-fill packing. Successful shipments of tree-ripe apricots have been reported. Try tight-fill packing of soft, ripe fruits first on a limited basis, using the packing and shipping suggested for peaches.

Many solid loads of cold plums have been shipped successfully. However, overloaded facilities or the desire to ship the fruit immediately sometimes results in incomplete cooling, so that spacing for air circulation in transit may be desirable.

Peaches and nectarines

Tight-fill packing of these fruits has shown promise in laboratory tests and trial shipments. Limited commercial shipments have been highly successful when the solid-spaced loading pattern was used to facilitate temperature management during transit. Because these fruits are often shipped at an advanced stage of maturity, and thus are very susceptible to impact and compression bruising, watch out for the following in tight-fill packing:

- Avoid overfilling.
- Use a pad on the bottom as well as on top of the container.
- Use a container of sufficient strength to support all weight during stacking and transit.
- Use container of sufficient depth to assure uniform settling.

Tight-fill packing does not appear to be adapted to those few early varieties which develop a soft tip while the shoulders remain hard.

Because peaches and nectarines are intermediate in respiration rates, always load them to allow air circulation. The solid-spaced load facilitates good temperature management during transit.

Cherries

Laboratory tests and limited trial shipments indicate that tight-fill packing would improve the delivered quality of sweet cherries. The present "loose pack" could be modified to a tight-fill pack with only minor procedural changes. Use top and bottom pads with this fruit.

Fill depths of 4 to 6 inches are acceptable with cherries. Deeper containers are undesirable, causing increased impact injury with compression and loosening of the fruit, and subsequently allowing increased transit injury.

Cherries are tender, subject to rapid deterioration, and have a high respiration rate, producing considerable heat which must be removed during transit. Cool cherries quickly and thoroughly before loading and space containers for air circulation during transit. The solid-spaced loading pattern offers possibilities for this fruit.

Apples

Limited tight-fill packing tests have been conducted with apples, with variable results. Tender varieties, such as Golden Delicious showed excessive impact bruising. A firmer variety, Yellow Newtown, was shipped sucessfully using the procedures recommended for peaches. The severity of the transit bruising problem with apples has not been thoroughly explored and requires further evaluations.

Other fruits

Limited evaluations and observations have also been made with oranges, avocados, and mature-green tomatoes. Tight-fill packing appears to have sufficient potential for all of these fruits to warrant further evaluations. Experience has ranged from preliminary laboratory tests with mature-green tomatoes, to laboratory tests and trial shipments with avocados, to observations of oranges under actual

packing and shipping conditions. No recommendations can be made for use of this packing method for any of these fruits without further extensive study, including laboratory tests, careful trial shipments, and limited commercial exploration.

Market acceptance

As the volume of tight-fill packed fruit has increased, problems of market acceptance have declined. Early resistance delayed the widespread adoption of tight-fill packing. The method appears to have important advantages to all handlers, but receivers were reluctant to try any variation from the place pack. Acceptance has been improving, however, as buyers have gained experience with consistent good arrivals of tight-fill packed fruit, and have become familiar with the ease of rehandling the product for bulk display or consumer packaging. Because of the advantages of this system to all fruit handlers, an industry-wide effort to speed its acceptance may be advantageous.

If you wish to read more about tight-fill fruit packing and other methods, the following publications are suggested:

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